Variations of the Earth's magnetic field during the last 3000 years

Since the 18th century, the Earth's magnetic field is continuously monitored by geomagnetic observatories. In order to investigate long term variations of the field, and to pin down possible mechanisms for the currently observed decrease of the Earth's field strength, longer observational ranges are necessary. To go further back in time, early historic observations from monasteries, mining companies and sailors are analyzed. In addition, geomagnetic field recordings stored in archeological fragments are used. Based on this data collection a global geomagnetic field reconstruction is conducted. The geomagnetic field model indicates the presence of large field variations in the past and allows for directly investigate possible relations e.g. to climatic variations.

Using a Bayesian inversion technique, which minimizes the total variational power at the core-mantle boundary under data constraints, a spherical harmonic geomagnetic field model is established for the Holocene period. This model is based on different collections of archeomagnetic data and historic geomagnetic observations. Using a bootstrap type statistical analysis the influence of data quality upon the reconstruction of the Gauss coefficients is analyzed. In particular, the influences of uncertainties in ages, magnetic field vectors as well as spatial and temporal distribution are investigated. Besides Gaussian data scatter, also the influence of systematic measurement bias is analyzed.

It is shown that data selection is very important regarding the resulting characteristics of the model. Furthermore, the analysis confirms that age uncertainties can lead to masking of short term field variations. The enormous spread in archeointensity and related ages uncertainties obfuscates underlying magnetic field variations for some regions. Including only the most trustworthy data into the inversion reduces the scatter in regional data and, most importantly, the possible bias.

The obtained model of field morphology indicates that most significant changes of the magnetic field vector, in particular archeo-magnetic jerks, are related to the dynamics of equatorial magnetic flux patches at the core mantle boundary. The predictive character of a global field model allows reconstruction of field evolutions of direction and intensity in time for any location (Fig. 1) and thus provides a powerful aid for archeomagnetic dating. Furthermore a detailed investigation of possible links between magnetic field and climatic variations (Gallet et al., 2004) is possible.

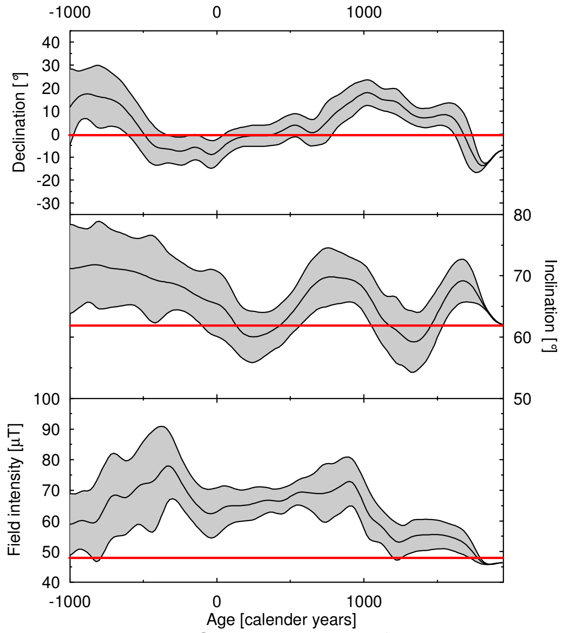

Figure 1: Geomagnetic field variation reconstructed for the Conrad Observatory during the last 3000 years. The red lines indicate the present day values.

References:

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